Temperature-Sensitive Medflies

There are millions of these six-legged bachelors in sunshine states like California and Florida. Because they're small and unobtrusive, you're unlikely to ever notice them. But their success in the game of love helps protect your favorite fruits and vegetables from becoming an icky, maggoty mess.

What are they?

Temperature-sensitive lethal Mediterranean fruit flies—or TSLs for short. Through a bit of laboratory trickery, TSL medflies that work outdoors are exclusively males. All of them are sterile—that is, infertile. Dropped from airplanes to work in areas where invading medflies have been detected, the TSL medflies have an important assignment: Find and mate with wild female Mediterranean fruit flies.

These fertile females would like to make a home for their offspring in warm-weather states. When they mate with sterile male medflies, however, no viable offspring are produced. Deprived of new generations of healthy young flies, the population soon crashes.

Now, 6 years of tests by USDA scientists and their colleagues in lush coffee plantations of southwestern Guatemala have shown that what's known as the Toliman strain of TSLs do their job anywhere from three to five times better than conventional, mixed-sex strains.

Temperature-sensitive lethal medflies get their name from the fact that high temperatures can be lethal to eggs containing TSL females. This genetic quirk in females was discovered by researchers working with the International Atomic Energy Agency in Vienna, Austria, about a decade ago.

The TSL trait allows mass-rearing of medflies that are exclusively males. And on a per-male basis, TSL males don't cost any more to rear than standard, mixed-sex strains of medflies. That saves resources that would otherwise go into producing the unneeded females. What's more, not having sterile females to

Geneticist Don McInnis collects a pair of mating medflies in an outdoor field cage during a mating competitiveness test.

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Male (brown) and female (white) medfly pupae. Pupae color was the basis of the old method of separating males from females.

Using temperature-sensitive lethal medflies, says ARS research geneticist Donald O. McInnis, is an effective, environmentally friendly strategy that helps reduce the need for chemical insecticides such as malathion. Medfly, *Ceratitis capitata*, is one of the world's worst insect pests of agriculture. It can infest more than 250 different kinds of fruits and vegetables and easily cost millions of dollars to eradicate. If it were to become established in California, for example, this industrious, one-third-inch-long insect could make a dent of anywhere from $324 to $510 million in the state's economy every year.

distract them once they are outdoors and looking for wild, fertile females may be a key to the TSL males' success.

To produce TSL males requires insectary workers to bathe the white, banana-shaped medfly eggs in 97 °F water for 12 to 24 hours. That kills all the eggs with female embryos inside but doesn't harm those with males. Later, when they are pupae—their final developmental stage before becoming adult flies—the insects are irradiated for several minutes to render them sexually sterile.

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Male medfly resting on a leaf.

Medflies ruin crops when fertile females use their tubelike ovipositors to punch holes in the skin of a ripening fruit or vegetable, then pump their eggs inside. The eggs hatch and produce wiggly medfly larvae that develop inside the fruit, feeding on the flesh and making it unmarketable. They eventually leave the fruit, dropping to the ground to continue their development into adult flies that begin the cycle all over again.

McInnis, who is at ARS' U.S. Pacific Basin Agricultural Research Center in Honolulu, Hawaii, helped design the pioneering tests of the Toliman TSL medflies in Guatemala. He did the work with David Lance of USDA's Animal and Plant Health Inspection Service, formerly at Waimanalo, Hawaii, and now at Cape Cod, Massachusetts; Pedro Rendon and colleagues with APHIS in Guatemala City, Guatemala; and co-researchers from the government of Guatemala.

Rendon and staffers at the International Atomic Energy Agency developed the Toliman TSL strain by crossing the Viennese TSL flies with a Guatemalan strain of medfly. Toliman TSLs needed for the collaborative research were produced at a medfly factory in El Pino, outside Guatemala City, Guatemala. APHIS and the Guatemalan government run that insectary.

Native to Africa, medflies have lived in Guatemala since at least the 1960s. The El Pino factory can produce up to about 50 billion medflies a year. Some are released in Guatemala, forming a living barrier that helps stop the species from advancing north into the United States. Other steriles are shipped to the United States for use in regional wars against medfly.

California, for instance, has an enormous need for steriles for its ongoing campaign in Los Angeles, Riverside, Orange, and San Bernardino counties.

The state last year used 15 billion steriles for this war on medflies. Florida has a similar campaign and uses 70 million

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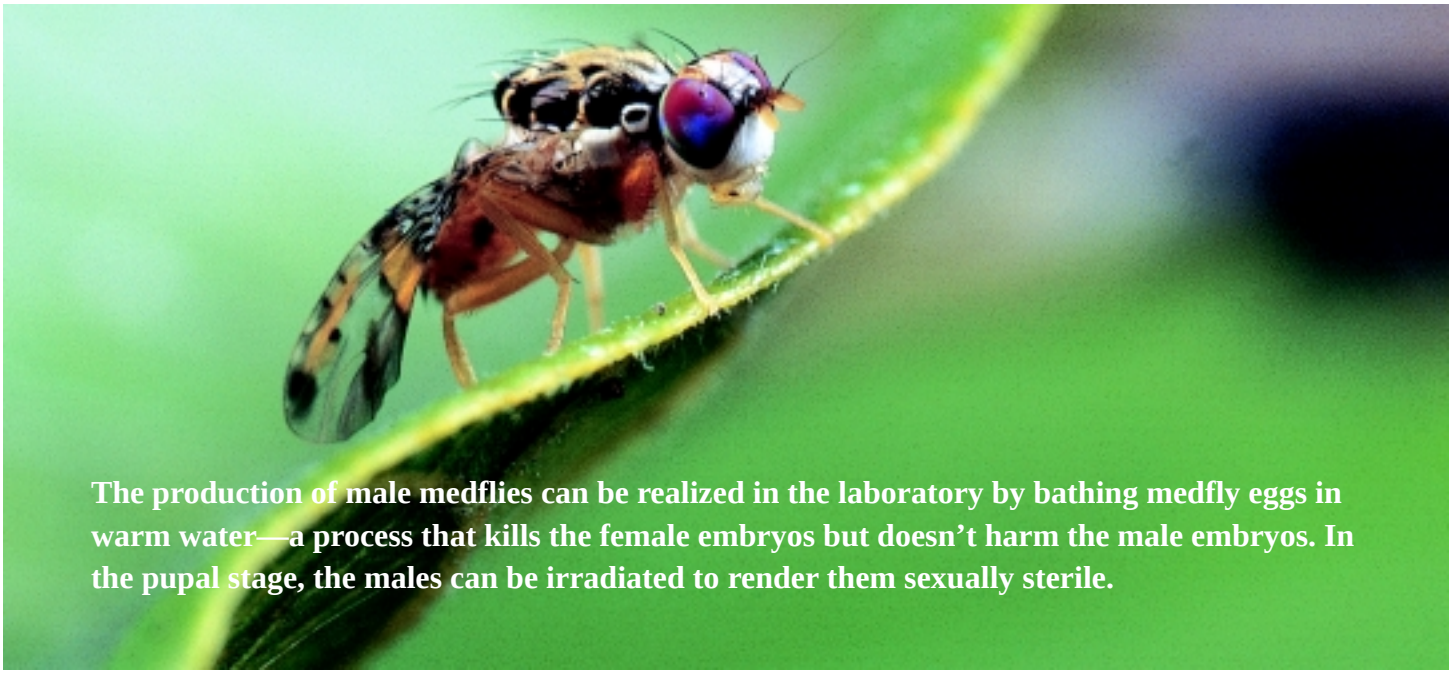

The production of male medflies can be realized in the laboratory by bathing medfly eggs in warm water—a process that kills the female embryos but doesn't harm the male embryos. In the pupal stage, the males can be irradiated to render them sexually sterile.

sterile medflies a week in a 500-square-mile area.

The Guatemalan studies, begun in 1993, included the largest-ever outdoor test of TSL medflies. For these rigorous examinations of the insects' proficiencies, more than 120 million Toliman TSLs and the lab's conventional "Petapa" strain of neutered medflies were set free in coffee fields.

As part of the experiment, researchers collected coffee berries that had been visited by the female flies to determine whether the hidden eggs were infertile. In plots where the Toliman TSLs had been released, the proportion of infertile eggs to fertile eggs was from three to five times greater than that of a standard lab-reared strain.

The Toliman TSLs also scored high in two other critical categories: field dispersal, or ability to roam throughout fields instead of staying in one place, and field survival, or ability to adapt to climate and other environmental conditions.

The ARS, APHIS, and Guatemalan investigators were the first to move TSLs out of the lab and into mass production. As a result of the team's exhaustive studies of Toliman TSLs, the El Pino fly factory is now planning to produce only this top-performing strain.

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Technician Steven Tam checks medfly eggs prior to heating them in a 97 °F water bath to kill the females.

Two major sterile-medfly factories in Hawaii—one operated by APHIS and the other by the State of California—also plan to produce TSLs exclusively. In all, they could provide more than 400 million steriles a week for mainland campaigns.

Largely because of the impressive results of the Guatemalan field tests with Toliman TSLs, other countries threatened by medfly invasions are opting to use TSLs in their own mass-rearing programs. Chile and the Portuguese island of Madeira, for example, are already using strains of top-performing TSLs to guard their crops against the ravages of wild medflies.—By **Marcia Wood,** ARS.

This research is part of Crop Protection and Quarantine, an ARS National Program (#304) described on the World Wide Web at http://www.nps.ars.usda.gov/programs/cppvs.htm.

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